

## Claims

We claim:

*Sub 1*  
A receiver for demodulating a data signal transmitted from a digital source at a network sampling rate that is synchronized with a network clock, comprising:

a two-stage interpolator, responsive to digital samples of the data signal, that generates interpolated digital samples in response thereto, the digital samples having a first local sample rate that is synchronized with a local clock and the interpolated digital samples having a second local sample rate that is synchronized with the network clock;

an adaptive fractionally spaced decision feedback equalizer, responsive to the interpolated digital samples, that generates equalized digital samples at the network sampling rate in synchronization with the network clock; and

a slicer, responsive to the equalized digital samples, that generates detected symbols therefrom corresponding to data from the data signal.

2. A receiver as recited in Claim 1, wherein the adaptive fractionally spaced decision feedback equalizer has a tap spacing given by  $pT/q$  where  $T$  is a modulation interval associated with the network sampling rate and  $p$  and  $q$  are integers.

*Sub 2*  
3. A receiver as recited in Claim 1, further comprising a clock synchronizer responsive to the detected symbols and generating a sampling index signal, the two-stage interpolator being responsive to the sampling index signal.

4. A receiver as recited in Claim 3, wherein the two-stage interpolator comprises:

a polyphase interpolator, responsive to the digital samples of the data signal, that generates first and second estimates for each of the digital samples of the data signal; and

a linear interpolator, responsive to the first and second estimates, that generates the interpolated digital samples.

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A receiver as recited in Claim 4, wherein the two-stage interpolator further comprises:

5 a time converter, responsive to the sampling index signal, that generates first and second integers in response thereto, the polyphase interpolator being responsive to the first integer and the linear interpolator being responsive to the second integer.

6. A receiver as recited in Claim 1, further comprising an echo canceller that couples a transmitter to the receiver, the echo canceller being responsive to transmit symbols from the transmitter that have a third local sample rate that is synchronized with the local clock and generating echo cancellation samples in response thereto at the first local sample rate in synchronization with the local clock.

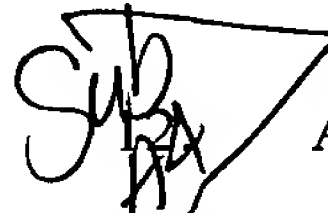
7. A receiver as recited in Claim 6, further comprising an adder that combines the echo cancellation samples with the digital samples of the data signal.

8. A receiver as recited in Claim 6, wherein the echo canceller comprises an adaptive digital filter, responsive to the transmit symbols from the transmitter, that generates echo cancellation samples at the first local sample rate in synchronization with the receiver clock, which are complementary to a portion in each of the digital samples of the data signal that can be attributed to an echo signal from the transmitter.

9. A receiver as recited in Claim 1, further comprising:  
means for identifying a signaling alphabet used by the slicer to generate the detected symbols.

10. A receiver as recited in Claim 9, wherein the means for identifying comprises:  
means for establishing a plurality of alphabet thresholds corresponding to valid data symbols;  
means for computing an average value for the equalized digital samples  
5 corresponding to a particular alphabet threshold; and  
means for updating the particular alphabet threshold with the average value.

11. A receiver as recited in Claim 1, wherein the detected symbols are pulse code modulation (PCM) codewords.

 A method for demodulating, in a receiver, a data signal transmitted from a digital source at a network sampling rate that is synchronized with a network clock, comprising the steps of:

sampling the data signal to produce digital samples at a first local sample rate that is  
5 synchronized with a local clock;


interpolating the digital samples to produce first and second estimates for each of the digital samples;

interpolating the first and second estimates to produce interpolated digital samples having a second local sample rate that is synchronized with the network clock;

10 equalizing the interpolated digital samples to produce equalized digital samples; and decoding the equalized digital samples to generate detected symbols therefrom.

13. A method as recited in Claim 12, wherein the equalizing step comprises the step of:

using an adaptive fractionally spaced decision feedback equalizer that has a tap spacing given by  $pT/q$  where  $T$  is a modulation interval associated with the network sampling  
5 rate and  $p$  and  $q$  are integers to produce the equalized digital samples.

 14. A method as recited in Claim 12, further comprising the step of:  
maintaining the synchronization between the second local sample rate and the network clock via a sampling index signal.

15. A method as recited in Claim 14, wherein the interpolating the digital samples step comprises the step of:

using a polyphase interpolator to produce the first and second estimates; and wherein the interpolating the first and second estimates step comprises the step of:

5 using a linear interpolator to produce the interpolated digital samples.

16. A method as recited in Claim 12, further comprising the steps of:  
coupling a transmitter to the receiver with an echo canceller;  
receiving at an input of the echo canceller transmit symbols from the transmitter that  
have a third local sample rate that is synchronized with the local clock; and  
5 generating at an output of the echo canceller echo cancellation samples at the first  
local sample rate in synchronization with the local clock.

17. A method as recited in Claim 12, further comprising the step of identifying a  
signaling alphabet for use in the decoding step to generate the detected symbols.

18. A method as recited in 17, wherein the identifying step comprises the steps of:  
establishing a plurality of alphabet thresholds corresponding to valid data symbols;  
computing an average value for the equalized digital samples corresponding to a  
particular alphabet threshold; and  
5 updating the particular alphabet threshold with the average value.

19. A method as recited in Claim 12, wherein the detected symbols are pulse code  
modulation (PCM) codewords.

5 20. A computer program product for demodulating, in a receiver, a data signal transmitted from a digital source at a network sampling rate that is synchronized with a network clock, comprising:

5 a computer readable storage medium having computer readable code means embodied therein, the computer readable code means comprising:

logic configured to sample the data signal to produce digital samples at a first local sample rate that is synchronized with a local clock;

10 first logic configured to interpolate the digital samples to produce first and second estimates for each of the digital samples;

second logic configured to interpolate the first and second estimates to produce interpolated digital samples having a second local sample rate that is synchronized with the network clock;

15 logic configured to equalize the interpolated digital samples to produce equalized digital samples; and

logic configured to decode the equalized digital samples to generate detected symbols therefrom.

21. A computer program product as recited in Claim 20, wherein the logic configured to equalize comprises:

5 logic configured to use an adaptive fractionally spaced decision feedback equalizer that has a tap spacing given by  $pT/q$  where  $T$  is a modulation interval associated with the network sampling rate and  $p$  and  $q$  are integers to produce the equalized digital samples.

22. A computer program product as recited in Claim 20, further comprising:

logic configured to maintain the synchronization between the second local sample rate and the network clock via a sampling index signal.

23. A computer program product as recited in Claim 22, wherein the first logic configured to interpolate comprises:

logic configured to use a polyphase interpolator to produce the first and second estimates; and wherein the second logic configured to interpolate comprises:

5 logic configured to use a linear interpolator to produce the interpolated digital samples.

24. A computer program product as recited in Claim 20, wherein the receiver further includes an echo canceller coupling a transmitter to the receiver, further comprising:

logic configured to receive at an input of the echo canceller transmit symbols from the transmitter that have a third local sample rate that is synchronized with the local clock; and

5 logic configured to generate at an output of the echo canceller echo cancellation samples at the first local sample rate in synchronization with the local clock.

25. A computer program product as recited in Claim 20, further comprising; logic configured to identify a signaling alphabet, the logic configured to decode being responsive to the logic configured to identify.

26. A computer program product as recited in Claim 25, wherein the logic configured to identify comprises:

logic configured to establish a plurality of alphabet thresholds corresponding to valid data symbols;

5 logic configured to compute an average value for the equalized digital samples corresponding to a particular alphabet threshold; and

logic configured to update the particular alphabet threshold with the average value.

27. A computer program product as recited in Claim 20, wherein the detected symbols are pulse code modulation (PCM) codewords.

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